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Wave-guided Optical Waveguides: Towards sculpted sub-micron light-matter interaction for broadband sources

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Creatively combining complementary approaches can realize advanced optical modalities that integrate an increasing number of functionalities and augment not just passive observation but also active access and control over the sub-micron world.[1,2] Using a merger of light and matter sculpting, we have 2PP-fabricated free-floating waveguides that can be optically trapped and “remote-controlled” in a volume; hence coined Wave-guided Optical Waveguides (WOWs). Combining micro-fabrication with optical trapping and manipulation allows us to exploit these WOWs in versatile and dynamically reconfigurable architectures.[3] A plurality of counter-propagating beam-traps relayed to the trapping volume by low-NA microscope objectives on our Biophotonics Worskstation (BWS)[4] control the WOW-structures demonstrating the possibility for a structure-mediated paradigm where micron-sized tools are used to achieve optical near-field tip-size access. However, realizing the full potential of this new structure-mediated approach in challenging microscopic geometries requires a versatile 3D light coupling that can dynamically track a plurality of WOWs to ensure continuous optimal light coupling on the fly.

To maintain high light throughput for the WOWs, we have integrated computer generated holography that can dynamically control the 3D focus position of the coupling beams. Our results show that we can simultaneously maneuver the WOWs in 3D space while dynamically coupling light through them [5]. Recently, we have reported that we can sculpt supercontinuum sources efficiently using the Generalized Phase Contrast (GPC) method [6]. The popularity of supercontinuum sources opens the possibility of using the WOWs in conjunction with the GPC method as a tool for light-delivery of reshaped broadband sources. The high refractive index of the WOWs suggests that they can be designed to act as tiny prisms to separate colors of light and thus act as tiny 3D-manueverable microscopic spectrometers. A more advanced technique of integrating disordered photonic structures can also be used such as described in literature on compact spectrometers [7]. This structure-mediated approach coupled with efficient beam shaping methods enables a host of new microscopic functionalities for a full sculpted light-matter interaction approach.

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